Experimental Investigation On Cylinder Vibration Analysis, Combustion, Emission and Performance Of An IDI Engine

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ABSTRACT

An experimental study was conducted to evaluate the performance, emissions, combustion and heat release rate of an Indirect Diesel Injection (IDI) engine fuelled with Mahua methyl ester (MME) along with Methanol (M) additive blends. Smoke, NOx, CO, HC and CO2 emissions were recorded and various engine performance parameters were measured. A comparative study was conducted using diesel, MME and Methanol additive blends on an IDI engine. There is substantial improvement can be observed from the net heat and cumulative heat release rate plots in which the 3% additive blend reached the performance of diesel fuel and the corresponding cylinder vibration plots indicated smoother combustion. Five additive blends were tested, the blending ratios of 1/99, 2/98, 3/97, 4/96 and 5/95 (by vol.) and five discrete part load conditions viz. No Load, 0.77 kW, 1.54 kW, 2.31 kW, and 2.70 kW loads without gear box and clutch assembly ensuring stable engine operation. 57% HC, 20% CO, 14% NOx, 27% smoke reductions were observed at 3% additive at maximum opted load (2.70 kW and 1500 rpm) of the engine.

KEYWORDS
Combustion Pressure, Exhaust Gas Emissions, Heat Release Rate, IDI Engine, Mahua Methyl Ester, Methanol, Vibration

1. INTRODUCTION

Biodiesel is as an attractive alternative fuel for replacement of conventional diesel with small or no changes made to the original design of the engine. 100% replacement entails some problems such as excess Nitrogen oxide (NOx) generation in the exhaust gases and crankcase oil dilution. Biodiesel made from non-edible oils is a safer choice. Mahua biodiesel (MME) is one of the many fuels receiving attention as an alternative fuel for diesel engines, and carries religious significance for being used in temples. Much work and research have been carried out on a Direct Injection (DI) diesel engine with biodiesel and additives. Research in biodiesel acknowledges its advantages and it is envisaged that the emissions can be substantially reduced. Biodiesel is an oxygenated fuel containing approximately 11% of O2 in its molecular structure. This may lead to the release of more NOx in the exhaust gas (Murugesan et al., 2009, Basha et al., 2009, Wu et al., 2009 and Sukumar Puhan et al., 2005). In this study, an effort has been made to reduce crank case oil dilution and NOx emission by adopting an Indirect Diesel Injection (IDI) engine.

IDI engines are suitable for the combustion of lower graded fuels and create the air entrainment in the swirl chamber and in the main chamber. The injection pressure employed is lower than that of DI engine and the compression ratio is higher (Turkcan and Canakci, 2011). Higher cetane fuels like...
biodiesel will create higher swirl in the pre combustion chamber leading to better combustion in the main chamber. Diesel fuel produces higher emissions and hence biodiesel is recommended in lieu of diesel fuel. Biodiesel increases NOx in tail pipe emission, which prompted to use methanol additive to create low temperature combustion. The additive Methanol’s boiling point is 64.7°C, latent heat of evaporation is 1.11 MJ/kg, cetane number is 4 and auto ignition temperature is 470°C (Rao and Rao, 2014). Hence methanol encourages low temperature combustion in the combustion process. However, it is necessary to investigate the Performance, emission and combustion propensity in the wake of knock and detonation in fuel burning. This aspect finally led to study on heat release rate and engine cylinder vibration analysis with alternate fuels.

Since biodiesel’s ignition delay is lesser than that of diesel fuel, its propensity of burning is better and hence there will be difference in the sharing of combustion in two combustion chambers. This aspect may create the scene of rapid combustion in one chamber and slower remnant combustion in the main chamber, which will obviously entail diminished torque conversion. Keeping this reason in view, methanol in small quantities is introduced in blended form with biodiesel to control combustion in the pre chamber. Seko and Kuroda et al., (2001 & 1998) have conducted a number of investigations on the use of neat methanol in CI engines. Consequently, if extensive mechanical modification is not the preferred option, methanol is generally limited to smaller percentages and is used as an additive. The use of methanol as an additive in CI engines has been investigated by a number of researchers. In general, it has been found that its addition improves engine performance, as indicated by higher BTEs. C.D. Rakopoulos (1992) conducted an experimental study to evaluate and compare the use of a diesel fuel supplement, specifically a 25/75% and a 50/50% blend of waste olive oil and commercial diesel fuel, in a four-stroke, DI diesel engine and in a four-stroke, IDI diesel engine having a swirl-combustion chamber. The influence of the blends (diesel fuel + olive oil), for a large range of loads has been examined on fuel consumption, maximum pressure, exhaust temperature, exhaust smokiness and exhaust-gas emissions such as nitrogen oxides (NOx), hydrocarbons (HC) and carbon monoxide (CO). The conflicts in the measured performance and exhaust-emission parameters, from the baseline operation of either engine are learned and compared. The study shows, for the DI and IDI engines, a small penalty in specific fuel consumption and a moderate increase in exhaust smokiness and essentially unaltered maximum pressures and exhaust temperatures when using the blends. Likewise, for both the DI and the IDI engines when using the blends, the study shows moderate decrease in emitted nitrogen oxides and increase in hydrocarbons as well as negligible increase in emitted carbon monoxide. Theoretical views of diesel engine combustion are used to assist the interpretation of the observed engines’ behavior. M.A. Kalam et al., (2011) have conducted an experimental study with waste cooking oil as biodiesel in an IDI engine. The utilization of waste cooking oil such as palm and coconut oil in diesel engines is more sustainable if they can perform similarly to ordinary diesel fuel (B0). This paper presents the experimental study carried out to evaluate emission and performance characteristics of a multi-cylinder diesel engine operating on waste cooking oil such as the 5% palm oil with 95% ordinary diesel fuel (P5) and 5% coconut oil with 95% ordinary diesel fuel (C5). B0 was used for comparability purposes. The outcomes indicate that there are reductions in brake power of 1.2% and 0.7% for P5 and C5 respectively compared with B0. The blended fuels reduce exhaust emissions such as unburned hydrocarbon (HC), smoke, carbon monoxide (CO) and nitrogen oxides (NOx). Jenkins S. H (1975) detected Noise from a diesel engine is caused by vibration of the surfaces of the structure, the accessories attached to the structure and covers such as valve covers and oil pan. Two basic forces cause the system to vibrate. Combustion is a major force, which generates pressure in the acoustically important frequency range of 0-10000 Hz. The engine mechanism also generates forces, which can be important in the same critical frequency range. These forces combine and cause the structure to vibrate in its preferred modes. Every harmonic of cylinder
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